The Absolute Radiometric Calibration of Earth-Observing Sensors Using Ground-Based Techniques

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Introduction

Ground-based vicarious techniques have been instrumental in ensuring that the data retrieved from airborne and spaceborne platforms are of the highest quality. The 40-year Landsat program is one example of a long-term data set that has benefited from vicarious calibration, and as more and more sensors are used to create Earth science data records, it becomes increasingly important to ensure that their radiometric calibration remains on the same SI-traceable scale.

The Remote Sensing Group of the College of Optical Sciences at the University of Arizona routinely collects vicarious calibration data at various test sites for the purpose of calibrating airborne and spaceborne sensors. The two main methods currently is use are the traditional reflectance-based approach, which uses ground personnel at a suitable test site, and more recently the Radiometric Calibration Test Site (RadCaTS), which is an automated facility at Railroad Valley, Nevada.

This work presents examples of the current radiometric calibration results obtained using the reflectance-based approach and RadCaTS for a variety of sensors including Landsat 8 OLI, Landsat 7 ETM+, Terra and Aqua MODIS, MISR, and the RapidEye constellation of satellites. The results are also used to analyze the uncertainty and scaling effects of RadCaTS when using sensors with spatial resolutions ranging from 5 m to 1 km.

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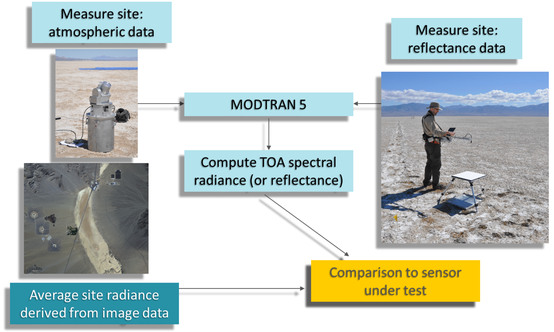
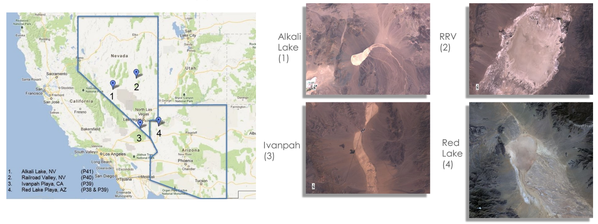
Ground-Based Vicarious Radiometric Calibration

The Remote Sensing Group at the University of Arizona uses the reflectance-based approach, where measurements of the atmospheric and surface properties are made during a sensor overpass. The input is used in the radiative transfer code MODTRAN to determine the top-of-atmosphere spectral radiance. The results are then compared to the sensor under test.



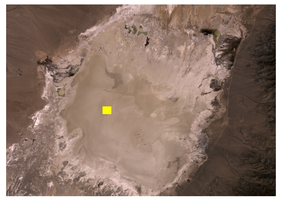
Test Sites

Test sites are typically dry lakes (playas) in arid regions. The Remote Sensing Group currently uses four main test sites in Arizona, Nevada, and California. The image below left shows the WRS-2 path for each of the sites, which are on the same approximate scale in the image below right.



Radiometric Calibration Test Site (RadCaTS)

RadCaTS was developed to supplement the in situ data that are collected by on-site personnel. The system resides at Railroad Valley, Nevada, and consists of three eight-channel, temperature-stabilized ground-viewing radiometers (GVRs), a Cimel sun photometer, and a meteorological station. It is based on the reflectance-based approach, and has been used to determine the radiometric calibration of sensors such as Landsat 7 ETM+, Landsat 8 OLI, Terra and Aqua MODIS, MISR, Hyperion, and RapidEye.



Landsat 8 OLI image of Railroad Valley, Nevada. The 1-km^2 RadCaTS test area is shown in yellow.

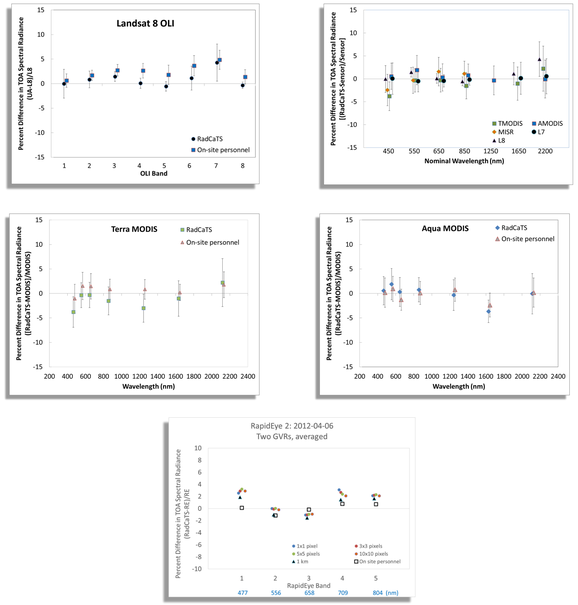
Ground-viewing radiometer at RadCaTS.

Data

The data used in this work consists of imagery from Landsat 7 ETM+, Landsat 8 OLI, Terra and Aqua MODIS, MISR, and RapidEye. Typically, Level 1 data that have been radiometrically calibrated and geolocated are used. The period of study for the RadCaTS work is from 2012–2013, while the in situ data with on-site personnel spans a larger period.

	Landsat 7	Landsat 8	MODIS	MISR	RapidEye
Bands	7	8	36	4	5
Wavelength (µm)	0.4–2.2	0.4–2.2	0.4–14.4	0.44–0.87	0.44–0.85
Pixel size (m)	30	30	250, 500, 1000	375	6.5

Results



Conclusions and Future Work

- RadCaTS provides results similar to those obtained using on-site personnel
- Salt on site will generally create a bias in the results because of decreased spatial uniformity
- Current results indicate that site should be treated as average of all GVRs
- RadCaTS has effectively supplemented data collection of on-site personnel
- Effective with sensors ranging from 5–1000-m spatial resolution
- Scaling effect study still requires more work
  - Upcoming RapidEye and Worldview 3 work in 2014
  - Continued comparison with Landsat 8 and on-site-personnel results
- Work in progress to define uncertainty of RadCaTS product
- Work in progress to automate the quality control of RadCaTS